Advanced Microfabrication Technologies for Microspacecraft

M. Ghezzo, B. Bagepalli, S. Kodiyalam, C. Korman, K. Browall
GE Corporate Research and Development, Schenectady, NY 12301

Norman Alexander, GE Astro Space Division, Princeton, NJ 08543

ABSTRACT

Advanced microfabrication technologies offer the prospect of reducing the weight and size of spacecraft through the use of lighter and stronger materials in conjunction with new mechanical/ structural design concepts and design optimization methods. At the same time electronic components have been scaled down while increasing functional utility. A two-fold benefit is derived for space applications through the use of less expensive components and lower launch costs associated with lighter components. GE-CRD is actively pursuing research in these key technologies for a wide range of applications including satellites. These key technologies will be reviewed and an update on GE progress will be given.

The need to reduce weight and lower cost, while maintaining product quality and reliability are primary drivers in the design of satellites, in general, and microsatellites in particular. For the structural subsystem, these requirements pose a complex design problem unless new mechanical design concepts and computer-aided design optimization methods are employed. Several new concepts like battery pack doubling as panel reinforcements and fuel tanks as integral structural members need to utilized. In addition, new viscoelastic material damping concepts for spacecraft components provide for lighter weight/lower cost designs, while satisfying the structural dynamics requirements.

High density interconnects (HDI) technology permits the use of bare ICs on a ceramic substrate with 90% active area utilization. A copper/polyimide multilayer structure is the backbone of the technology, which has demonstrated a size/weight reduction of >10x compared to printed circuit board with performance up to the GHz level. HDI modules have exceptional mechanical robustness as evidenced by survival of 180 Kg rapid acceleration tests.

Microelectromechanical systems (MEMS) are redefining sensors and actuators by miniaturization through micromachining techniques. Sharing many fabrication steps with HDI we have developed a new technique for surface micromachining of copper/polyimide structures using computer-aided laser patterning. Millimeter-size electromechanical switches have been made with dielectric isolation > 200 v, maximum current density of 10^5 amp/cm^2, contact resistance of 20 μohm cm^2 and interrupt time of a few milliseconds.

HDI technology leads to a significant reduction of power supply size, as demonstrated by the 5x5x.5 cm^3 dimensions of a 1 MHz Dual Forward Resonant Power Supply. Integrated circuits, capacitors and transformers are either embedded in an HDI structure or made by a copper/polymide process. Efficiencies > 80% have been predicted with a power density of 4W/cm^3.

Inorganic coatings on polymers allow the surface properties of structural materials to be engineered for space applications, while achieving weight reduction commensurate with the substitution of polymers for metals. For example, metal coatings can increase resistance to oxygen plasma attack in LEO orbits, reduce EMI/RFI interference, or reduce thermal degradation.

MICROSPACECRAFT FOR SPACE SCIENCE IN ISAS, JAPAN

by Hirobumi Saito
Institute of Space and Astronautical Science, Japan

ABSTRACT

The Institute of Space and Astronautical Science (ISAS) in Japan has launched 21 spacecraft into orbit for since 1970, and has proceeded steadily in various fields of space research. The size and weight of the spacecraft developed have been selected to be small in order to keep their low cost and short development phase. This presentation shows the compact style to deal with space in ISAS. Also, the several microspacecraft for planetary missions are presented. The video film is performed to introduce the ISAS space activities.

Microtechnologies
and
Applications to Space Systems Workshop

SPACE STATION, SHUTTLE & PROPULSION